LIFE16 ENV/ES/000419

Responsible reduction of nitrates in the comprehensive water cycle

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Action: B4. Development of a political action plan

Responsible: Diputación Provincial de Valencia

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This report has been produced within the Project **LIFE LIBERNITRATE Responsible reduction of nitrates in the comprehensive water cycle (LIFE16 ENV/ES/000419),** as a deliverable of Action B4. Development of a political action plan.

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TABLE OF CONTENTS

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1. CONTEXT AND ENVIRONMENTAL PROBLEM

Water pollution by nitrates of agricultural origin is a widespread environmental problem worldwide. The development of intensive agriculture and the introduction of new farming techniques have led to the use of large quantities of fertilisers (mainly nitrates and phosphates) and other agrochemicals, causing the accumulation of these organic and inorganic chemicals in the soil.

The use of chemical fertilisers has increased from 14 million tonnes in 1954 to 200.5 million tonnes in 2018. Nitrogen fertilisers trigger harmful environmental processes, such as eutrophication, acidification, pollution of water resources and emission of nitrogen oxides (NOx). In Europe, 87% of groundwater contains excess nitrates (European Environment Agency). In areas of intensive crop and livestock farming, the concentration of nitrate in groundwater can reach up to seven times the legal limit. The number of areas vulnerable to this pollution has increased in recent years, especially in Romania, Belgium, Spain, Sweden, Germany and the UK. Studies have shown that the effectiveness of soil management measures to reduce nitrate levels in rivers and groundwater is limited. New strategies are needed to accelerate the recovery of EU water bodies from nitrate pollution.

The EU Directive 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption obliges Member States to establish the necessary measures to ensure the wholesomeness and cleanliness of water intended for human consumption. Among the minimum requirements for water to be fit for human consumption, it establishes a nitrate concentration limit of 50 mg/l in water intended for human consumption.

In the province of Valencia, especially in the area of La Ribera, the nitrate concentration values in groundwater for human consumption are, in many places, above 50 mg/L.

Within this framework, the LIFE LIBERNITRATE project proposed an innovative project to reduce the concentration of nitrates in the integral water cycle. This project aims to implement an innovative, simple, economical, sustainable and transferable integrated system.

This project carries out a sustainable circular economy process based on the valorisation of rice straw ash for the reduction of nitrates in the integral water cycle (Moliner al.,2018).

This project promotes the use of other alternatives as a solution to the problem of nitrate contamination of water, since up to now reverse osmosis systems have mainly been used, which, although an effective solution, is economically costly for small municipalities and involves greater water consumption.

The project has been coordinated by Consorci de la Ribera (CRIB), with the participation of Aguas de Valencia SA (AVSA), Provincial Council of Valencia (DIVAL), Stichting Incubator (LWI), Università degli Studi di Genova (UNIGE), La Unió de Llauradors i Ramaders del Paísd Valencià (UNIO), Polytechnic University of Valencia (UPV) and University of Valencia (UVEG). It is a project in which all the affected agents participate: public administrations, universities, farmers, water managers, and business incubators, thus closing the cycle and guaranteeing the proper implementation of the project presented.

2. OBJETIVES

The main objective of this proposal is to reduce the concentration of nitrates in the integral water cycle by implementing an innovative, simple, economical, sustainable and transferable integrated system based on the use of an adsorption bed made of active silica from the ashes produced by the controlled burning of rice straw.

The objective of this strategy was twofold:

- To reduce the negative effects of rice straw burning in the field.

- To reduce the nitrate content in water by using modified silica obtained after rice burning.

This double objective directly addresses the problem addressed by the LIFE programme as well as the problem of the destination of rice straw, an extremely important issue in Spain and Italy, which produce 80% of the rice grown in the European Union.

Specific targets for the effectiveness of the system are set as follows:

- Elimination of organic and inorganic nutrients from water intended for human supply in small towns, complying with the requirements established in water quality legislation.
- To reduce drinking water treatment costs compared to other systems, reducing energy consumption.
- To integrate the project in the general policies of the EU and to promote a political intervention plan that promotes specific lines of financing in the Operational Programmes.
- Implement a comprehensive system to raise awareness among farmers to promote the use of low environmental impact fertilisers.
- Draw up a business plan and disseminate the technology at European level for the installation of this project in other territories with the same problem.
- Promote the sustainability, replicability, transferability and transnationality of the proposed strategies and innovations in the EU as a whole.
- To disseminate and publicise the results obtained to users, clients, territorial agents and society in general.

In order to achieve the objectives described as well as the specific goals, the project has hinged on the validation of a prototype for the preparation and implementation of active silica beds to reduce the concentration of nitrates in the water cycle by acting:

1. On the headwater (from groundwater) and rejection water in an osmosis plant.
2. On well water for human consumption in small municipalities to reduce nitrate concentration to below 50 ppm, without the use of an osmosis plant.

3. METHODOLOGY

In the development of a pilot project carried out in a drinking water treatment plant, active silica has been used. The objective of this project is to reduce the nitrate concentration in the water cycle by 30 %, firstly by studying well water and the reject water from an osmosis plant.

In order to achieve this objective, several prototypes have been developed within the framework of the project:

- An incineration plant of our own design. The design of the unit is highly customised, taking into account the main quantitative objectives and possible technical difficulties.

- A prototype to produce active silica from the controlled incineration of rice straw to obtain silica-rich ash.

- Several prototypes for the preparation and application of active silica beds to reduce nitrate concentration in the water cycle by acting (a) on the collector water (from groundwater) and reject water from an osmosis plant; and (b) on drinking well water in small municipalities to reduce nitrate concentration to below 50 ppm, without the use of an osmosis plant.

Figure 1: (a) incineration plant; (b)extraction and functionalisation reactor; (c) prototypes of silica beds.

Figure 1 shows (a) the incineration plant consisting of four elements: storage, conveyor belt, incineration unit and gas treatment section, (b) extraction and functionalisation reactor, and (c) silica prototypes.

Several controls are used in the different elements of the plant (i) temperature controllers: inlet air, combustion chamber, flue gas, ash container; (ii) inlet feed flow and belt speed; and (iii) volumetric flow: inlet air and flue gas. All these variables are monitored by a controller that can work automatically following the defined working conditions. All elements of the system follow a safety criterion to ensure that they remain in the safest form in case of failure.

The pellets enter the combustion chamber from the dosing silo through the feed pipe regulated by a rotary valve (Moliner, Bove and Arato, 2020). Air is transported from the outside to the combustion chamber through an air conveyor. Inside the combustion chamber, two spark plugs (250 W each) are installed on the rear surface of the combustion chamber (length = 140 mm). Downstream of the combustion chamber, a fume fan is installed with a double function (i) to extract the fumes from the combustion chamber to the outside; and (ii) to ensure air intake. A box (length = 0.19 m; width = 0.304 m; height = 0.094 m, for a total volume = 0.0055 m3) is placed at the bottom of the chamber to collect the ash produced during combustion. The chamber is closed with an insulated door with a glass window to observe the flame and visually control the process. Four temperature sensors (top, flue gas outlet, combustion chamber hearth and ash collector) are placed inside the chamber and their measurements are recorded in the controller.

4. RESULTS

During the four years of implementation of the LIBERNITRATE project and within the project, the following actions have been carried out:

1.- Obtaining the title of the Patent of Invention of the process of adsorption of nitrates in water or aqueous solutions by means of modified silica from rice straw ash Patent ES2020 / 070099

Fertilisation of three plots dedicated to the cultivation of persimmon, citrus and rice with slow release fertilisers. The results show a reduction in nitrogen fertiliser consumption of more than 20% with no reduction in production. This practical experience will help to convince farmers of the suitability of using this type of fertiliser.

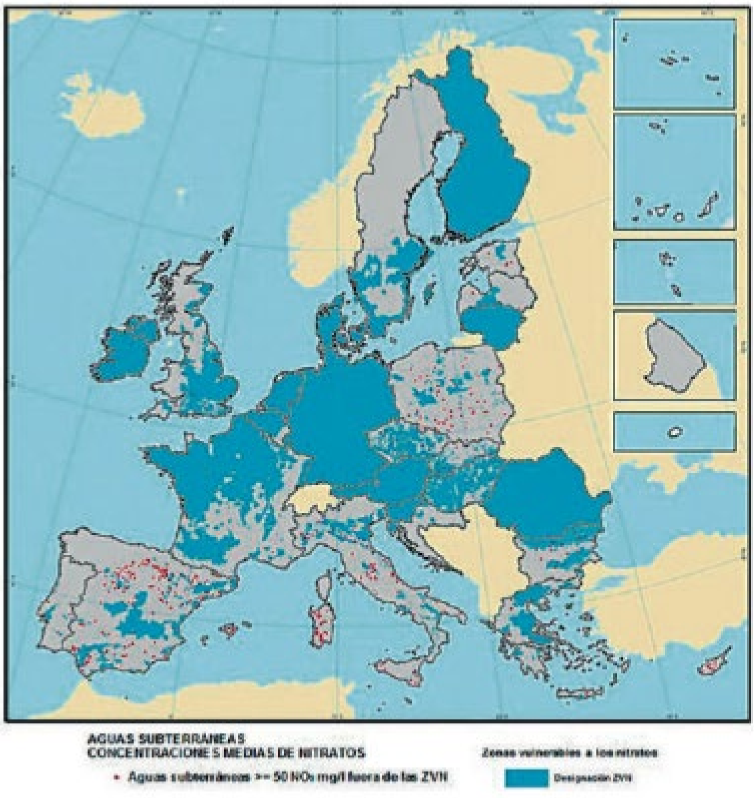
3.- Design and installation of the full-scale pilot plant in the town of Alginet.

4. Development of an online self-training course on responsible fertilisation in nitrate vulnerable areas. This course aims to overcome the general lack of awareness of this problem in the farming community and to highlight the practical importance that the reduction of nitrogen fertilisation will have after the new EU Common Agricultural Policy.

This course is divided into six modules in video format in English, Italian and Spanish (with subtitles in other languages), which can be watched independently. It is available on the Youtube channel of the project. The course modules are:

A. Fertilisation: basic notions.
B. The Nitrates directive and vulnerable zones.
C. Determination of nitrogen in the soil.
D. The new common agricultural policy: good farming practice.
E. The fertilisation programme.
F. Practical cases on responsible fertilisation: the LIBERNITRATE project.

5 Identification of areas affected by nitrate pollution at European level as well as the main economic sectors, besides municipal supply, that could benefit from the technology.



EU-28 Nitrates Directive. Area designated as nitrate vulnerable zone and groundwater monitoring stations with average nitrate concentrations above 50 mg/l located outside ZVN, period 2021-2015.

Reference source: Report from the Commission to the Council and the European Parliament on the implementation of Directive 91/676/EEC.

6 Drafting a business plan to promote the use of this technology in other territories at European level.

7 Dissemination of information on project results in regular newsletters, audiovisual media, specialised congresses, attendance at fairs, contacts via social networks, specific information offices.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ACTION B1

5. PROJECT TRANSFERABILITY AND BUSINESS PLAN

In order to make this technology transferable and replicable, a business plan has been developed in which the potential market has been analysed.

During the design of this business plan it has been detected that, in addition to the municipal drinking water supply market, the technology developed in the LIBERNITRATE project (silica filters) can potentially be applied in other sectors, farms, greenhouses, although at the current moment of development of the project it is considered convenient to focus the effort on small municipalities that can supply their inhabitants with quality water in an efficient and economical way

In any case, the business plan establishes an analysis of the environment taking into account the different options available on the market, the average prices of these options, the number of municipalities with less than 200 inhabitants (a total of 70 municipalities, which represents 14.11 % of the total number of municipalities in the province of Valencia).

		ZA (<200 hab. // >50 mg/l Nitratos) (*)	
PROVINCIA	**ZA <200 hab.**	**Valor absoluto**	**Porcentaje %**
CASTELLON	141	3	2,13
VALENCIA	269	63	23,42
ALICANTE	86	4	4,65
TOTAL COMUNITAT VALENCIANA	496	70	**14,11**

Based on this data, the extrapolation to the rest of Spain has been quantified at 1,200 cities that could adopt this solution.

Taking this data into account, the Business Plan designs 3 scenarios, according to different assumptions, as can be seen in the following table

Sales price per litre of water cleaned	Gross profit at 50% of villagers in all 1.200 villages	% inhabitants villages that need to switch to Libernitrate to break even
21 cents (average price bottled water)	22.368.000 euro per year	4.5%
9 cents (cheapest bottled water alternative)	1.344.000 euro per year	31%
1,3 cents (cheapest comparable filter, Brita)	n.a.	n.a.

Therefore, and even considering the above data, it should be noted that the prototype object of the project has been obtained, which has been shown to have the capacity to be used and marketed, although it should be considered that this is the first phase of a longer development process until it reaches the point of being marketed and making a profit. At the present time, after having completed the LIBERNITRATE study, it is estimated that it has reached TRL level 5 (product tested in a controlled environment).

For this reason, and given the level and point at which the project is at, it is worth highlighting the possibilities of attracting resources from the European Union, both from the Next Generation funds and from the Multiannual Financial Framework 2021-2027, aimed at financing projects that promote the ecological and digital transition and the circular economy promoted by the LIBERNITRATE project. As indicated above, this technology, as well as being applicable to various sectors, could be used not only in the drinking water treatment phase, but also in the purification phase, to treat the water used by certain industries, avoiding the discharge of water with high concentrations of nitrates into the environment. It will also be necessary to analyse other sectors and the purpose of the final results: silica with nitrates.

6. BENEFITS AND IMPACTS

Throughout the life of the project, comparative analyses have been carried out, both environmental and social and economic, of the currently existing water purification technology, mainly the reverse osmosis plant or the purchase of bottled water, and the technology developed by LIBERNITRATE.

The key indicator to measure the socio-economic impact of the project is the number of potential replications. This information is relevant because of its influence on the number of inhabitants benefited, the jobs created, the presence of economies of scale and, ultimately, the viability of the project itself. Health indicators have also been identified as socio-economic aspects related to the project.

Prioritisation criteria have been established to implement the project in those areas with the greatest potential for generating social, economic and health benefits. These potential benefits will be greatest in areas where the nitrate problems are most severe, and the barriers to achieving a solution are greatest. Situations where the cost of inaction is highest should have the highest priority for intervention. This cost of inaction is a key indicator when prioritising actions and determining the benefits derived from them. When the cost of implementing the project is much lower than the cost of inaction, a favourable socio-economic impact is guaranteed. Monetary valuation methods have been proposed to quantify the cost of inaction or, in other words, the benefits of taking action. According to the results obtained, the LIBERNITRATE project will be viable through scalability. Scalability will increase the competitiveness of the project and reduce unit production costs, facilitating large-scale implementation.

7. CONCLUSIONS

Nitrate contamination of water is a widespread problem at European level, sometimes affecting human supplies.

In order to meet the requirements of drinking water quality legislation, water supply managers need to use techniques to remove nitrates from water.

Nitrate removal by adsorption of silica filters derived from rice straw ash is a safe solution to the surplus of rice straw in regions such as Spain and Italy.

Given the effectiveness and environmental benefits for the elimination of nitrates from water intended for human consumption, at a lower cost and with a smaller environmental footprint than other more widespread systems to date, such as reverse osmosis.

The system does not generate waste and means a reduction in water consumption compared to other systems such as reverse osmosis, where around 40% of the volume of treated water is rejected as brine. There is also a very significant reduction in energy consumption.

The system has been shown to be suitable, under certain parameters, to supply a population of 200 inhabitants, but it will be easily scalable to other population sizes by adapting the size of the filters.